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Association of moisture content in mulberry leaf with nutritional parameters of bivoltine silkworm (*Bombyx mori* L.)

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Abstract: The effect of feeding mulberry leaves with different moisture contents on the 5th instar bivoltine silkworm (CSR3 × CSR6) was studied. For this purpose tender leaves (with moisture 80% - 85%), medium leaves (with moisture 65% - 70%) and mature leaves (with moisture 55% - 60%) were provided to silkworm. The growth, nutritional indices and nutritional efficiency parameters were studied and worked out by standard gravimetric procedure. The results indicated that nutritional parameters like ingesta, digesta, approximate digestibility, reference ratio and consumption index were recorded significantly higher in batches fed with higher moisture content leaves. Similarly, nutritional efficiency parameters like conversion efficiency of ingested and digested food into larvae, cocoon and shell were recorded significantly higher in batches fed with higher moisture content leaves. However, there was no significant difference observed between treatments in the case efficiency of conversion of digested food into shell and digesta required to produce one gram of shell.

Key words: *Bombyx mori*; leaf moisture content; nutrition efficiency; consumption; assimilation; conversion

1 INTRODUCTION

The role of moisture in determining productivity in sericulture is generally recognised but doesn't appear to have been critically evaluated and properly appreciated. Hence, judicious use of water/moisture has to be followed for obtaining maximum productivity and improvement to produce quality cocoon. The quality of mulberry leaves was determined mainly based on moisture content (Kumar *et al*., 1996). Higher moisture content of mulberry leaves is one of the important factors and has a direct effect on growth and development of silkworm. Moisture content in mulberry leaves favorably affects their ingestion, digestion and also the conversion of nutrients in silkworm. Dietary water intake of silkworm is directly related to the moisture content of mulberry leaf and the amount of food intake (Shajahan, 1992). The method and extent of dietary water intake and loss are complex, interrelated and continuously exchanging phenomenon (Delvi *et al*., 1988). The food consumption and utilization is influenced by various biotic and abiotic factors (Reynolds and Nottingham, 1985). The accumulation of body matter or growth of the larvae depends on the dietary efficiency. Nutrition is the important physiological process, which plays a prime role in the growth and in turn affects the productivity of the silkworm. Rashid *et al*. (1993) reported that growth rate and digestibility of any insect depends on nutritional value and water content of food. Water content in mulberry leaves is considered as one of the criteria in estimating the leaf quality (Paul *et al*., 1992). In the present study, an attempt was made to study the effect of feeding mulberry leaves with different moisture contents on the 5th instar bivoltine silkworm on nutritional and growth parameters of the silkworm and also analysed the association of moisture content of mulberry leaves with different nutritional parameters of the 5th instar silkworm.

2 MATERIALS AND METHODS

2.1 Insects

A new productive bivoltine hybrid silkworm (CSR3 × CSR6) suitable to rear during favourable season (Aug. - Feb.) under Indian environmental condition was used. Rearings were conducted following the new standard package and recommendation (Rajan *et al*., 2001) by providing fresh leaves of V1 mulberry variety. The temperature (27℃ - 28℃ and 23℃ - 25℃) and humidity (85% - 90% and 65% - 70%) during young age and late age silkworm rearing respectively was maintained.

2.2 Food utilization experiments

The food utilization study was confined to the 5th

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instar larvae as 80% – 85% of the total leaf is consumed in this instar. After the resumption from 4th moult, 50 larvae each for 3 replications were separated for 3 treatments and kept in a sericatron (environmental chamber with precise and automatic control facilities for uniform maintenance of temperature and humidity). The 3 treatments (T1, T2 and T3) were provided different maturation level mulberry leaves with different moisture content (T1: tender mulberry leaves with moisture 80% – 85%; T2: medium level mulberry leaves with moisture 65% – 70%; T3: mature mulberry leaves with moisture 55% – 60%). Known quantities of fresh mulberry leaves following the recommendation (Rajan *et al.*, 2001) were provided to the silkworm thrice a day and before each feeding moisture content of mulberry leaf sample was estimated using infrared moisture determination balance.

Sample of mulberry leaves used for each feeding was placed in separate tray as dummy for dry weight determination of ingesta. Additional larval batches of each treatment were maintained in parallel to determine the dry weight and for subsequent determination of daily increment in larval weight (Maynard and Loosli, 1962). The healthy larvae were counted daily in each replication of every treatment and unequal, unhealthy and dead larvae were removed and replaced from additional batches. The litter was collected carefully on subsequent days of feeding. The excreta and leftover leaf in the litter were manually separated and dried in oven. Observation on larval weight and larval duration were recorded and for dietary efficiency calculation dry weight of leftover leaf, excreta, larval weight gain, cocoon weight and shell weight were recorded for all the replications of each treatment.

From these data the nutritional parameters and indices like ingesta, digesta, approximate digestibility percentage (AD%), reference ratio (RR) and consumption index were calculated. Similarly nutritional efficiency parameters like efficiency of conversion of ingesta and digesta (ECI and ECD) to larval body, cocoon and shell, and ingesta and digesta per gram (I/g and D/g) of cocoon and shell were worked out by standard gravimetric method as described by Waldbauer (1968).

2.3 Data analysis

The experiment was repeated three times and the pooled data were subjected to statistical analysis to find out the level of significance. Analysis of variance (Anova) was worked out under Randomized Block Design (RBD) to arrive at the treatment significance levels. The treatment mean values were compared using values of critical difference (CD). Correlation analysis was also conducted to find out association of moisture content of mulberry leaf with nutritional parameters.

3 RESULTS AND ANALYSIS

Growth of silkworm fed with leaves with different moisture contents were studied by preparing growth curve. The curve represents the growth of silkworm larva taken place during particular period time. The curve indicates that higher growth and larval body weight gain was recorded in batches fed with leaves with higher moisture content, and also in this treatment the growth phase was completed quicker than other treatments. In batches fed with mature leaves less growth was recorded and more time taken to complete the maturation (Fig. 1). Tender leaves were nutritionally superior to medium and mature leaves. The soluble protein, sugars and moisture content are higher in top tender leaves, and this might have contributed for increased larval weight (Bongale *et al.*, 1991; Basu *et al.*, 1995).

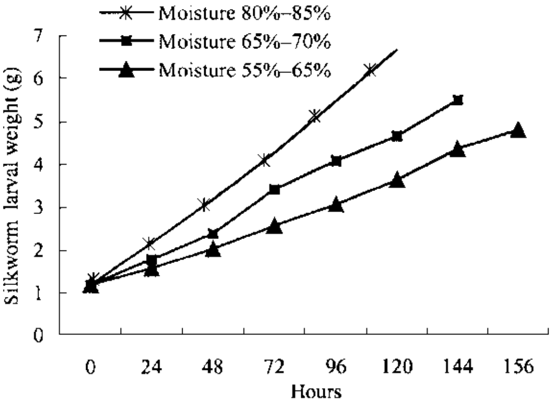

Fig. 1 Growth curve of 5th instar silkworm fed with leaves with different moisture contents

The food consumption has a direct relevance on the weights of larvae, cocoon, pupae and shell. The independent parameters of consumption and productivity are depending on the type of nutrition (Shivakumar, 1995) and silkworm breeds (Ramadevi *et al.*, 1992). Significantly higher ingesta were recorded in T1 (4.805 g), followed by T2 (4.529 g) and T3 (3.855 g) (Table 1). This indicated that higher moisture in mulberry leaves leads to higher food intake in silkworm. Similar observations were made by Paul *et al.* (1992). The same trend was also observed in the case of digesta and significantly higher digesta was recorded in T1 (1.978 g). These results were in agreement with Paul *et al.* (1992). Digesta is the quantity of food assimilated, which is affected by various factors. Since the digestibility differs in different breeds and condition, the proportion of food intake and production of faecal matter also varied (Ramadevi *et al.*, 1992). However, no significant difference of excreta was found in between 3 treatments (Table 1).

Digestibility is affected by nutritional deficiency or imbalanced diet, high content of crude fibre and water deficiency in the feed（Waldbauer, 1964）. Significantly higher approximate digestibility was recorded in T1（41.16%）, followed by T2（32.21%）and T3（29.04 %）（Table 1）. The higher assimilation efficiency or approximate digestibility is certainly a racial character, as higher food intake does not necessarily results in higher digestibility（Magadum *et al*., 1996）.

Reference ratio（RR）is an indirect expression of absorption and assimilation of food. It also expresses ingesta required per unit excreta production. Highly significant difference in RR was observed between different treatments and highest RR was recorded in T1（1.70 g）.

The consumption index also referred as feeding rate at which nutrients enter in to digestive system. Significantly higher consumption index（CI）was recorded in T1（0.727）, followed by T2（0.603）and lowest in T3（0.433）.

The efficiency of food ingested and converted to larval body matter varied prominently among hybrids and under different feeding and environmental conditions（Rahmathulla *et al*., 2002）. Significantly higher efficiency of ingested food into larval body matter（ECI larva）was recorded in T1（29.69%）, followed by T2（24.83%）and T3（19.06%）（Table 2）. Similar trend was recorded in the case of ECD larva and highest conversion percentage was recorded in T1（78.77%）. These results were in agreement with results of Paul *et al*.（1992）. Pathak and Ashish（1998）also recorded direct correlation between the moisture content of leaves, body water content of larvae and amount of urination.

ECI and ECD to cocoon and shell are the efficiency parameters having the paramount importance in practical sericulture（Trivedi and Nair, 1998）. The efficiency of conversion of the ingested food into body substance depends on the food digestibility and its nutrition（Waldbauer, 1964; Bailey, 1976）. Significantly highest ECI cocoon was recorded in T1（18.21%）. However, there was no significant difference between T2 and T3（Table 2）. But, significant difference of ECD to cocoon was observed between 3 different treatments.

Leaf-silk conversion rate（ECI and ECD to shell）composed of 3 basic factors, *i.e.* digestibility, the rate of transforming digested food into cocoon and cocoon shell ratio. Significantly higher ECI shell was recorded in T1（13.53%）, followed by T2（10.87%）and T3（9.93%）（Table 2）. However, no significant difference of ECD to shell was recorded between three treatments. These results were in contrary to Paul *et al*.（1992）.

Silkworm of different breeds require different

Table 1 Nutritional efficiency parameters of the 5th instar larva of bivoltine hybrid silkworm fed with leaves with different moisture contents

Treatments	Ingesta (g)	Excreta (g)	Digesta (g)	Approximate digestibility (%)	Reference ratio	Consumption index
T1（Moisture 80% – 85%）	4.805	2.827	1.978	41.16	1.70	0.727
T2（Moisture 65% – 70%）	4.529	3.071	1.459	32.21	1.48	0.603
T3（Moisture 55% – 60%）	3.855	2.736	1.120	29.04	1.41	0.443
CD@ 5%	0.1067		0.110	1.798	0.064	0.012
CD@ 1%	0.1107		0.141	1.990	0.094	0.018
± *SE*	0.054		0.032	0.421	0.019	0.009
	**	NS	**	**	*	**

Significant at 1% level, * Significant at 5 % level. CD: Critical difference.（Values of food intake are expressed in gm/larva/5th instar on dry weight basis）

Table 2 Nutritional efficiency parameters of the 5th instar larva of bivoltine hybrid silkworm fed with leaves with different moisture contents

Treatments	ECI Larva (%)	ECD Larva (%)	ECI Cocoon (%)	ECD Cocoon (%)	ECI Shell (%)	ECD Shell (%)	I/g Cocoon (g)	I/g Shell (g)	D/g Cocoon (g)	D/g Shell (g)
T1（Moisture 80% – 85%）	29.69	78.77	18.21	44.23	13.53	32.88	5.50	7.39	2.26	3.04
T2（Moisture 65% – 70%）	24.83	72.39	16.31	50.66	10.87	33.75	6.13	9.21	1.96	2.97
T3（Moisture 55% – 60%）	19.06	65.018	16.12	55.49	9.93	34.18	6.21	10.08	1.80	2.93
CD@5%	1.551	5.538	0.521	4.352	0.113		0.1158	0.2313	0.121	
CD@1%	1.752	6.012	0.845	4.672	0.181		0.1570	0.4210	0.241	
± *SE*	0.241	1.98	0.224	2.12	0.092		0.071	0.091	0.018	
	**	*	*	**	**	NS	*	*	*	NS

** Significant at 1 % level * Significant at 5 % level

ECI: Efficiency of conversion of ingesta; ECD: Efficiency of conversion of digesta; I/g Cocoon: ingesta per gram cocoon; I /g Shell: Ingesta per gram shell; D/g Cocoon: Digesta per gram cocoon; D/g Shell: Digesta per gram shell.

Table 3 Correlation between moisture content of mulberry leaves and nutritional efficiency parameters of the 5th instar silkworm

	Ingesta	Digesta	Approximate Digestibility	Reference ratio	ECI cocoon	ECD cocoon	ECI shell	ECD shell	I/g cocoon	D/g cocoon	I/g Shell	D/g Shell
R value	0.967**	0.982**	0.9582**	0.9480**	0.870**	0.983**	0.960**	0.619**	– 0.872**	– 0.974**	– 0.974**	0.623**

quantum of feed to produce cocoon and shell under different conditions. Significantly lowest ingesta required to produce one gram of cocoon was recorded in T1 (5.50 g) followed by T2 (6.13 g) and T3 (6.21 g). This indicated higher feed conversion efficiency of silkworm when fed with leaves with higher moisture content. However, non-significant difference was observed between T2 and T3.

Similarly, ingesta require to produce one gram of cocoon (I/g cocoon) was recorded significantly least in T1 (7.39 g) and highest was recorded in T3 (10.08 g). This indicated more feed conversion efficiency of silkworm larvae fed with higher moisture content leaves.

Digesta require to produce one gram of cocoon was recorded least in T3 (1.80 g) and highest was recorded in T1 (2.26 g). However non-significant difference of D/g shell was observed between 3 treatments.

Correlation study was conducted to find out the association of moisture content of leaves with various nutritional parameters. The results indicated that there is a highly significant association of all nutritional parameters with moisture content of mulberry leaves. However ingesta and digesta required to produce one gram of cocoon are negatively correlated with moisture content.

4 CONCLUSION

The study results concluded that feeding leaves with higher moisture content to the 5th instar silkworm has a direct impact on growth, food assimilation and conversion efficiency in silkworm. The tender leaves (with moisture 80% - 85%) fed batches recorded significantly higher food intake, assimilation and conversion efficiency. The growth of silkworm was higher in batches fed with tender leaf and the growth phase was completed in a shorter time. So, the sericulturist has to increase the moisture content of mulberry leaves by frequent irrigation and enriching the soil with higher moisture.

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不同水分含量桑叶对二化性家蚕的营养效应

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摘要：研究了取食不同水分含量桑叶对二化性家蚕(CSR3 × CSR6)5龄幼虫的影响。实验设嫩叶(水分含量80% ~ 85%)、半成熟叶(水分含量65% ~ 70%)和成熟叶(水分含量55% ~ 60%)3个不同处理。采用标准重量分析法分析和计算各种生长、营养和营养效率指数。结果表明，在取食较高水分含量桑叶的处理中，营养指数(包括取食量、消化量和近似消化率等)和营养效率指数(包括食物利用率和转化率等)均显著较高，但不同处理中消化食物向茧壳的转化率及产生每克茧壳所需食物消化量差异不明显。结论是取食水分含量高的桑树嫩叶有助于提高家蚕的取食和营养。

关键词：家蚕；桑叶水分含量；食物利用率；消化；吸收；能量转换

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